

# Causes of the Desertification in Hulunbuir Prairie and Its Prevention and Control Measures

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## Abstract

Maintaining the ecological safety of China is strategically significant taking a particular example of the protection and conservation of the ecosystem of Hulunbuir Prairie in China's northern region. A lengthy period of development and excessive utilization coupled with two decades of drought in Hulunbuir Prairie has brought about varying degrees of damage to Hulunbuir Prairie and rapid grassland desertification. This paper analyzes the Hulunbuir Prairie desertification and its causes, concluding that desertification has been aggravated by harsh natural conditions, along with human factors such as inefficient use of resources, overgrazing, unauthorized cultivation, and unlawful herbal medicine collection at Hulunbuir Prairie. It is also showed that thin soil layers are potentially dangerous of contributors in the desertification of Hulunbuir Prairie. Furthermore, various measures are proposed to prevent and control the desertification of Hulunbuir Prairie, including laws on the supervision and utility of grasslands, to maintain a balance between foraging and livestock; as well as prohibition, delay, and rotation of grazing; more reasonable allocation of stock capacity, optimization of industrial distribution, construction artificial pasture and forage crops, establishment of a basic system to sustainably protect grassland and pasture, and development of a mechanism of compensation for grassland ecology and environmental management.

## Keywords

*Hulunbuir Prairie; Grassland Desertification; Climate Variation; Overgrazing; Prevention And Control Measures*

## Introduction

This desertification – land degradation in arid, semi-arid, and dry sub-humid areas resulting from various factors, including climatic variations and human activities – is becoming one of the world's most serious

environmental problems (Glenn E et al, 1998). Six million hectares of land are turned into desert every year with consequent economic losses estimated to be 42.3 billion US dollars. In China, in particular western China, the overuse and misuse of land has contributed to a number of serious environmental problems, especially desertification (Danfeng Sun et al, 2007).

Hulunbuir Prairie, a gem located in the eastern Eurasian prairie, is well known due to its appropriate temperature, large number of rivers, availability of water, and lush grass, with a famous semi-humid prairie in the temperate zone of the world. As the most northerly prairie in China, it is a natural well-protected prairie in relatively good order, known as the "green and pure land" and the "North China jasper".

The Hulunbuir Prairie ecosystem not only plays an extremely important ecological role in Hulunbuir city in many ways, for example climate regulation, water conservation, restraining sand movement, preventing desertification, and conservation of water and soil, but also provides protection in flood seasons for water systems of the Nunkiang and Ergun rivers. It is the key to taking flooding in the Songhua River and Liyoohe Bira valleys in permanent control, and is a green ecological barrier of northeast and north China. However, the desertification of Hulunbuir Prairie is becoming serious as a result of unauthorized reclamation of grassland, overgrazing, and other factors. Hulunbuir Prairie is facing an increasingly serious ecological crisis which needs urgent attention. At present, the desertification in Hulunbuir Prairie has become a big concern in terms of the ecological security

of Hulunbuir city, which is ranked the fourth largest desertified grassland following the Horqin desert, the Mu Us desert and the Hunshandake desert (Huiying Zhao, 2007). Hulunbuir Prairie in Inner Mongolia Autonomous Region has become one of the most severely desertified ecological regions of China over the last several decades and represents serious desertification of grassland as the result of expanded regional economic growth initiatives and continued population pressure. This study takes the Hulunbuir Prairie as a case to analyse the present conditions of desertification and its causes, which suggests measures to prevent and control the desertification.

## Study Area and Methods

### *Study Area*

Hulunbuir City located in the northeast of Inner Mongolia Autonomous Region, north China (ranging from 115°31' to 126°04' E and from 47°05' to 53°21' N) with an approximate area of  $25.64 \times 10^4$  km<sup>2</sup> generally belonging to plateau landscape, as a part of the Mongolian Plateau in central Asia, is under the control of both the tectonic zones of the North East Neocathaysian tectonic belt and the East-West complex structural belt. Since the Da Hinggan Ling spans the middle part of Hulunbuir City from northeast to southwest, three large economic and geomorphic areas have been formed from west to east: Hulunbuir plateau plain, Da Hinggan Ling mountain, and the alluvial plain of Piedmont Hill on the right bank of the Non Ula.

The area has a continental monsoon climate with the middle latitude temperate zone and a cold temperate zone which leads to lower temperatures, a bigger temperature range, and violent summer and winter changes, resulting being one of the cold regions in China. The average annual temperature is about -5 to -2°C. Affected by landform and monsoon, the distribution of precipitation is uneven, and the inter-annual variation is also great. Annual mean precipitation is 394 mm, most of which is concentrated in June to September, amounting to 70%–80% of the annual total precipitation in the city.

Hulunbuir City administers 13 banners and districts, and the GDP of the city in 2009 amounted to 78 billion yuan (RMB, the same below), which is increasing by 17.1% this year. Urban per capita disposable income in

the city is 13,298 yuan and the per capita net income of farmers and herdsmen is 5,606 yuan, which is increasing by 9.9% and 10.8%, respectively.

### *Methods*

Land degradation is studied at different scales (local, regional, national, and global) depending on the magnitude, severity, causes, and extension affected by observed changes and size of the total region (Dahlberg A C, 2000; Gray L C, 1999; Riksen M J, 2001). The methods to obtain information and evaluate the desertified land degradation status were aided by the Second National Land Survey in Hulunbuir City, and the Third National Land Degradation and Desertification Monitoring results and field investigation in 2008 and 2009. Field work was carried out covering most of the study area to identify and evaluate the present characteristics as well as processes of desertification. The climate data from previous studies has been detailed analysed on environment degradation of Hulunbuir City were conducted.

### *Desertified Grassland Distribution and Its Area*

Desertified grassland in Hulunbuir Prairie ranging from 47°20' to 49°50' N encompasses three sand belts as its core area and shows an irregular distribution. The northern sand belt known as Hailar belt is distributed along both sides of the Manzhouli to Hailar railway. It ranges from the West Hill in Hailar Region at its eastern beginning to the Cuogang pasture land in New Barag Left Banner, which is 90 km in length. The middle sand belt starts from Mohertu in Evenk Autonomous Banner then passes Xini River, Yimin River, the upstream part of Hui River, and Baritu in New Barag Left Banner, finally reaches the Halaha River, on the border between China and Mongolia, which is 150 km in length. The southern sand belt starts from Amgalang Town in New Barag Left Banner and reaches to the Huisumu in Evenk Autonomous Banner, which is 80 km in length and 15 km in width (Yaozhi Zhou et al, 2006). Regarding the distribution of the administrative area, Hulunbuir desertified grassland mainly located in Evenk Autonomous Banner, New Barag Left Banner, New Barag Right Banner, Old Barag Banner, Hailar Region, and Manzhouli City, is related to 33 townships (town or Sumu). Furthermore, there are  $0.22 \times 10^4$  hectares of desertified grassland in Hailar Region, accounting for 0.17% of the total amount of desertified grassland in Hulunbuir City, and these two data respectively are

133.33 hectares and 0.01% in Manzhouli City, 243.1 thousand hectares and 18.63% in Evenk Autonomous Banner, 24.1 thousand hectares and 1.85% in New Barag Right Banner, 797.1 thousand hectares and 61.07% in New Barag Left Banner, and 238.5 thousand hectares and 18.27% in Old Barag Left Banner. According to the Third National Desertification Monitoring results of 2004, the area of desertified land in Hulunbuir City approximate to  $130.5 \times 10^4$  hectares is now spreading at an annual rate of 66.7 thousand hectares, which has had a serious impact on economic and social development in the city.

#### ***Desertified Grassland Distribution Types and Degrees in Hulunbuir City***

There are four types of desertified grasslands in Hulunbuir City: mobile desertified land, semi-fixed desertified land, fixed desertified land, and exposed desertified land, among which the areas are different. Four different degrees of desertification and areas have

been determined (Table 1).

#### ***Desertified Grassland Distributions by Different Levels of Vegetation Coverage***

Areas of desertified grassland distributions by means of different levels of vegetation coverage are shown in Table 2.

#### ***Dynamic Variation of the Desertified Grassland***

Although the ecological situation of some key recovery areas of desertified grassland in Hulunbuir City has been initially improved, and the recovery schedule in local regions is more rapid than the rate of progress of the desertification, it is shown that the level of desertification has become worse, which the inside of the desertified grassland takes on active, and that the outside is expanding. From the point of view of the desertification development trend, desertified spots in some areas such as along the rivers in grazing districts, both sides of roads, around pumping wells, near the

TABLE 1 DESERTIFICATION AREAS AND LEVELS OF HULUNBUIR GRASSLAND ( $\times 10^4$  HECTARES)

Level of sandiness	Total	Mobile desertified land	Semi-fixed desertified land			Fixed desertified land			Exposed desertified land
			Subtotal	Artificial semi-fixed desertified land	Natural semi-fixed desertified land	Subtotal	Artificial fixed desertified land	Natural fixed desertified land	
Total	130.5	2.8	9.1	2.7	6.5	75.0	26.8	48.2	43.7
Mild desertification	106.2					62.6	19.9	42.7	43.7
Moderate desertification	12.4					12.4	6.9	5.5	
Severe desertification	9.1		9.1	2.7	6.5				
Very severe desertification	2.8	2.8							

Source: The Third National Land Degradation and Desertification Monitoring Results of 2004.

TABLE 2 AREAS OF DESERTIFIED GRASSLAND DISTRIBUTIONS BY DIFFERENT LEVELS OF VEGETATION COVERAGE OF HULUNBUIR GRASSLAND ( $\times 10^4$  HECTARES)

Levels of vegetation coverage (%)	Total	Mobile desertified land	Semi-fixed desertified land			Fixed desertified land			Exposed desertified land
			Subtotal	Artificial semi-fixed desertified land	Natural semi-fixed desertified land	Subtotal	Artificial fixed desertified land	Natural fixed desertified land	
Total	130.5	2.8	9.1	2.7	6.5	74.9	26.7	48.2	43.7
<10	2.8	2.8							
10-19	2.7		2.7	1.2	1.5				
20-29	6.5		6.5	1.5	5.0				
30-39	4.2					4.2	0.6	3.6	
40-49	6.5					6.5	5.5	1.0	
50-59	2.4					2.4	1.1	1.3	
60-69	27.5					20.3	10.8	9.5	7.2
70-79	19.6					14.2	2.5	11.7	5.4
$\geq 80$	58.3					27.3	6.2	21.1	31.0

Source: The Third National Land Degradation and Desertification Monitoring Results of 2004

sources of potable water, all around the herdsmen's settlements and towns, and newly ploughed grassland have gradually increased. Furthermore, with the increasing of carrying capacity and expanding of the land reclamation area, combined with the increasingly dry climate, the desertification process of a large number of potentially desertified lands is accelerating (Haogang Nie et al, 2005). Dynamic variation of the desertified grassland is shown in Table 3.

TABLE 3 DYNAMIC MONITORING RESULTS OF THE DESERTIFIED LAND IN HULUNBUIR CITY FOR TWO PERIODS ( $\times 10^4$  HECTARES)

Year of monitoring	Total area	Mobile desertified land	Semi-fixed desertified land	Fixed desertified land	Exposed desertified land
1999	87.6	4.0	6.1	77.5	
2004	130.5	2.8	9.1	74.9	43.7
Difference between the two years	42.9	-1.2	3.0	-2.6	43.7
Average annual rate of change (%)	9.79	-5.83	9.67	-0.67	

Source: The data come from results of The Second National Land Degradation and Desertification Monitoring in 1999 and The Third Monitoring in 2004.

## Results and Discussion

### *The Harsh Natural Conditions Aggravating Desertification in Hulunbuir Prairie*

The climatic factor is the key to the impact of ecological and environmental changes on the grassland. Since 1950s, global average temperature has increased by  $0.5^{\circ}\text{C}$  and the average temperature in the Northern Hemisphere has increased by  $0.6^{\circ}\text{C}$ . According to the statistics of the 160 weather stations in China, the average temperature from 1991 to 2000 was  $12.90^{\circ}\text{C}$ , which is  $0.68^{\circ}\text{C}$  above the average temperature from 1951 to 1960 (Mingzhi Li et al, 2003). Under the influence

of the warmer temperature and widespread droughts all over the world, the climate has already changed in Hulunbuir Prairie where less raining and more wind are in spring, and the evaporation capacity is high, which leads to exacerbation of the level of grassland desertification. The annual average temperature of desertified grassland in Hulunbuir Prairie from 1961 to 2005 showed a trend of rise, and the annual precipitation decreased more significantly from 2001 to 2005, while evaporation during the same period increased significantly (Tables 4 – 6).

TABLE 4 THE CHANGE IN AVERAGE TEMPERATURE OF DESERTIFIED LAND IN HULUNBUIR DURING DIFFERENT PERIODS AND DIFFERENT SEASONS ( $^{\circ}\text{C}$ )

Different periods	Annual average temperature	Spring	Summer	Autumn	Winter
1961–1970	0.6	7.0	19.2	6.1	-18.3
1971–1980	0.4	6.4	19.4	6.2	-17.4
1981–1990	0.8	7.4	19.1	6.4	-16.8
1991–2000	1.0	8.2	19.8	6.7	-15.5
2001–2005	1.0	8.1	21.0	7.9	-16.7

TABLE 5 THE CHANGE IN ANNUAL PRECIPITATION OF DESERTIFIED LAND IN HULUNBUIR DURING DIFFERENT PERIODS AND THE DIFFERENT SEASONS (mm)

Different periods	Annual average precipitation	Spring	Summer	Autumn	Winter
1961–1970	258.0	29.7	186.7	32.0	9.5
1971–1980	278.4	23.1	194.9	46.8	13.7
1981–1990	291.0	31.9	209.8	34.0	15.8
1991–2000	292.7	28.6	29.7	45.0	14.1
2001–2005	225.4	29.5	181.0	32.2	22.6

TABLE 6 THE CHANGE IN ANNUAL EVAPORATION CAPACITY OF DESERTIFIED LAND IN HULUNBUIR DURING DIFFERENT PERIODS AND DIFFERENT SEASONS (mm)

Different periods	Annual average evaporation capacity	Spring	Summer	Autumn	Winter
1961–1970	1671.0	502.6	812.2	278.0	104.5
1971–1980	1614.0	466.9	805.3	253.8	88.6
1981–1990	1526.1	452.3	752.6	237.8	81.8
1991–2000	1555.7	456.9	740.5	244.7	109.7
2001–2005	1815.1	469.3	847.9	344.1	153.7

***Human Factors such as Less Efficient Development of Resources, Overgrazing, Unauthorized Cultivation, and Unlawful Herbal Medicine Collection Have Intensified The Desertification In Hulunbuir Prairie***

Firstly, in recent years mineral resources such as coal and oil in the four banners dominated by animal husbandry in Hulunbuir City have been developed constantly, and the development level has intensified, leading to excessive exploitation of resources, a relatively extensive development model, and a lower level of comprehensive resources development as well as utilization, which aggravated the level of damage to the grasslands to a certain extent.

Secondly, human factors such as overgrazing and unauthorized cultivation are the main causes leading to the desertification in Hulunbuir Prairie. In recent years, grassland animal husbandry in Hulunbuir City has developed rapidly, but the main model of development is still extensive and expanded reproduction, that is to say, it relies heavily on the increases in the quantity of livestock to develop animal husbandry. The situation has caused the problem of relative overloading in some regions, and this predatory model of production has resulted in the grassland desertification.

Thirdly, as a force driven by the immediate interests, large areas of grasslands have been reclaimed into farmlands which are concentrated in the best quality meadow grassland zone in which there has been various vegetation types and a wide variety of plants. Once contiguous grasslands were cultivated, they were fully exposed in winter and spring, and a lot of organic matters was eroded and lost. This procedure was repeated again and again, after 2–3 years, the grassland soil fertility developed over millions of years almost was disappeared into the sandy sequence, and forced abandonment of the grasslands occurred. Furthermore, new high quality grasslands were reclaimed, and consequently the areas of grasslands became smaller and smaller and otherwise the desertified areas of grasslands. With the continuous increase in cultivated land area, the amount of grassland in the region has dropped significantly since the 1960s.

Fourthly, in order to benefit from the precious herbs in Hulunbuir Prairie, many people have dug up the herbs unlawfully on a large scale, leading to destruction of grassland vegetation and increased grassland desertification.

***The Fact That The Soil Layer Is Thin is a Potential Dangerous Factor in The Desertification of Hulunbuir Prairie***

Since the soil layer in the Hulunbuir grassland is thin and the sand bed is thick, if land surface is exposed in grassland, the wind will easily blow away fine sand under the soil layer, creating enormous wind erosion pits, and the desertification will be difficult to be in control (A-MunkhDalai Zhang et al, 2006).

**Conclusions and Policy Implications**

The relationship between climatic variability and desertification is complex, partly because it is compounded by the impact of land use. Great changes have taken place in Hulunbuir Prairie during the last 50 years, especially the last 30 years, among which the temporal-spatial changes in the water environment, vegetation degeneration, and the extent of desertification are the most obvious aspects. These changes have led to a decrease in the land capacity, and desertification of Hulunbuir Prairie shows an accelerating tendency at the present time. Such changes in the environment have natural and anthropo-genic causes. Climate changes (mainly the increasing temperature) have not only intensified evaporation but also caused a decrease in the amount of wetland, meanwhile, unreasonably grazing has resulted in the degeneration of vegetation and land desertification. The speed and magnitude of ecoenvironmental degradation have affected the biodiversity, population, and community adaptation. Changes in these ecosystems in Hulunbuir Prairie could influence sustainable development in the region. Generally, natural changes are the factors inducing environment degradation, whereas here man-made changes are the main reasons. Therefore, to avoid further deterioration of the environment and ecosystems, it is important to establish and implement ecosystem protection planning. Some effective measures are essential in this respect, including technical and political considerations. Policy approaches to desertification should be focused on sustainable land use, which means that a wide range of biophysical and social processes, including climate variability and climate change, must be addressed together.

***Supervising and Utilizing Grasslands by Law***

The relevant laws and regulations such as the Grassland Law should be seriously implemented, the grasslands should be administered by law, and the system of

supervision of grasslands should be improved. The stock-carrying capacity of pastures should be scientifically and rationally determined, the amount of livestock should be determined by the grass situation, and rotational grazing should be implemented to prevent overgrazing. Grassland law enforcement should be strengthened and illegal cases concerning grasslands should be severely punished to ensure rational exploitation and permanent utilization of grassland resources.

***Maintaining a Balance Between Foraging and Livestock, Prohibiting Grazing, Suspending Grazing, Rotational Grazing, and Allocating Stock Capacity Reasonably to Utilize The Grassland Rationally***

The extensive management and administration models of herders should be transformed, and the stock-carrying capacity of pastures should be allocated depending on different levels of grass yield. Restrictions on the quantity of grazing should be put, and division into rotational grazing areas should be put into practice to ensure sufficient time for regeneration of the grass. Through adjustment of the herd structure and improvement of the animal husbandry techniques, applicable agricultural and animal husbandry science and technology should be significantly popularized and applied to shorten the livestock-rearing periods and raise the rate of marketing of fattened stock.

***Optimizing Industrial Distribution, and Advocating and Implementing Intensive Land Use***

Development of industry in the grassland area must be cautious, and national macro-industrial policy should be analysed seriously. Considering the resource conditions and industrial development, the regional industrial distribution should be fully optimized in Hulunbuir City. Development of industry in grassland and grazing districts must adhere to scattered distribution, and enterprises should be located at the industrial zone to achieve high standards and intensive utilization of land. Predatory styles of exploitation should be resolutely forbidden everywhere in the grasslands to avoid pollution followed by the need for recovery. The expanding capacity renovations and the quality improvement as well as upgrading of the existing industrial enterprises should be strengthened to constantly enhance the self-development capacity of the enterprises. The development of the industrial zone should be effectively enhanced, and investment construction funds should be increased. The direction of development of the industrial zone should be clear and

definite, and the level of industry should be advanced to strengthen the economic capabilities of the industrial zone and to improve farmers living standard. In order to reduce the pressure of rapid population growth, when it comes to the development of resources in less developed areas, the practice of blindly moving in large numbers of people should be changed, and ordinary labourers should be found at the location of the resource development.

***Setting up a Basic System to Protect Grassland and Pasture Permanently***

In accordance with principles such as definite property rights, land control, economical and intensive land use and strict management, the delimitation, protection, and management of the permanent basic grassland should be carried out more rapidly. The approval procedures of expropriation and occupation of the basic grassland should be strict to ensure that the quantity of the permanent basic grassland does not decrease, the usage does not change, and the quality does not degrade.

***Building up the Compensatory Mechanism for Grassland Ecology And Environment***

It is necessary to improve initiatives concerning grazing districts and herders to strengthen the protection of ecological resources. People should be placed first to promote the building of a society where there is harmony between humans and nature, between different groups, and between humans and society, and land and water resources should be protected to build a scientific and sensible energy utilization system. A national direct subsidy system for ecological protection should be implemented as soon as possible to establish an ecological compensation mechanism for grassland. Combined with the effects of ecological protection in the key grassland protected areas, the amounts of transfer payments and allowances from Government's finances should be increased year by year.

***Constructing Artificial Pasture and Forage Crops***

Building an artificial fodder base to improve the production capacity of artificial forage is a strong momentum in the restoration and reconstruction of the degraded grassland. Expansion of the production capacity of artificial fodder will strengthen the fundamental substance of livestock produce and raise the productivity of the individual livestock, in addition, commercialization of the livestock should be accelerated to achieve the return of grazing land to grassland and to realize rehabilitation to promote and

transform grassland animal husbandry from traditional extensive management to intensive and semi-intensive management.

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